Inter-comparison of AIRS Version-6 CERES Edition-4, and MERRA-2 OLR Time Series

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Background

This presentation compares characteristics of 3 sets of monthly mean Level 3 (L3) OLR data products covering the 14 year period September 2002 through August 2016:

CERES EBAF Edition 4.0

AIRS Version-6

MERRA-2

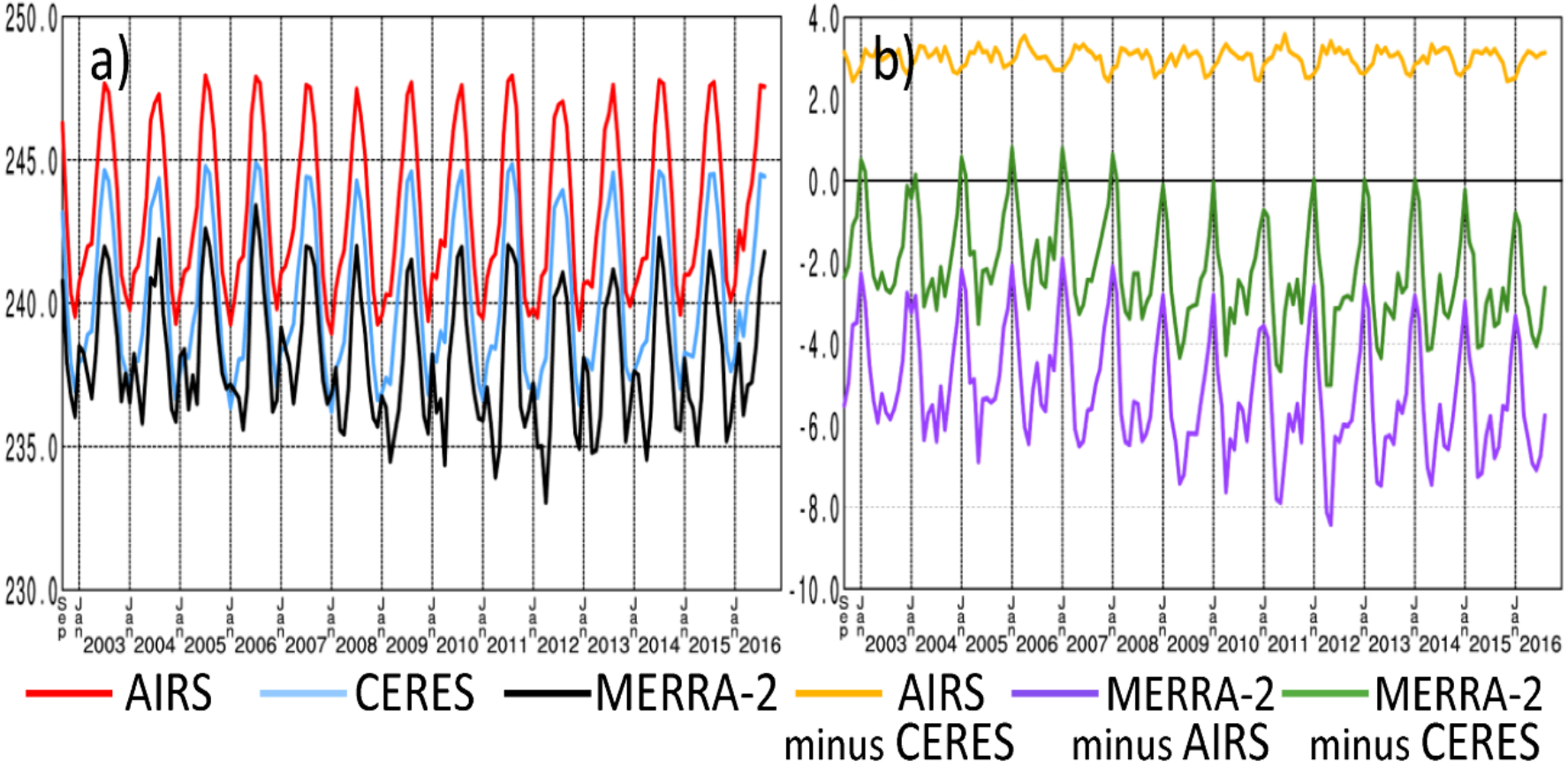
All data are on a 1° latitude by 1° longitude spatial grid.

Particular attention is paid to the levels of agreement of global mean OLR time series, sample monthly mean OLR climatologies, and anomaly time series.

AIRS, CERES, and MERRA-2 OLR Data

- AIRS Version-6 OLR is computed using an OLR RTA in conjunction with retrieved geophysical parameters.
  AIRS products shown use the average of the AIRS products generated separately at roughly 1:30 AM and 1:30 PM local time.
- CERES_EBAF Edition 4.0 OLR is derived from measured fluxes. CERES OLR represents what would have been observed if measurements were taken over the coarse of the whole day.
- MERRA-2 OLR is a computed product, generated on a grid point basis every 6 hours: 0Z, 6Z, 12Z, and 18Z. MERRA-2 uses a different OLR RTA than does AIRS, and uses model generated, rather than retrieved geophysical parameters.

Global Outgoing Longwave Radiation (Watts/m^2)
September 2002 through August 2016

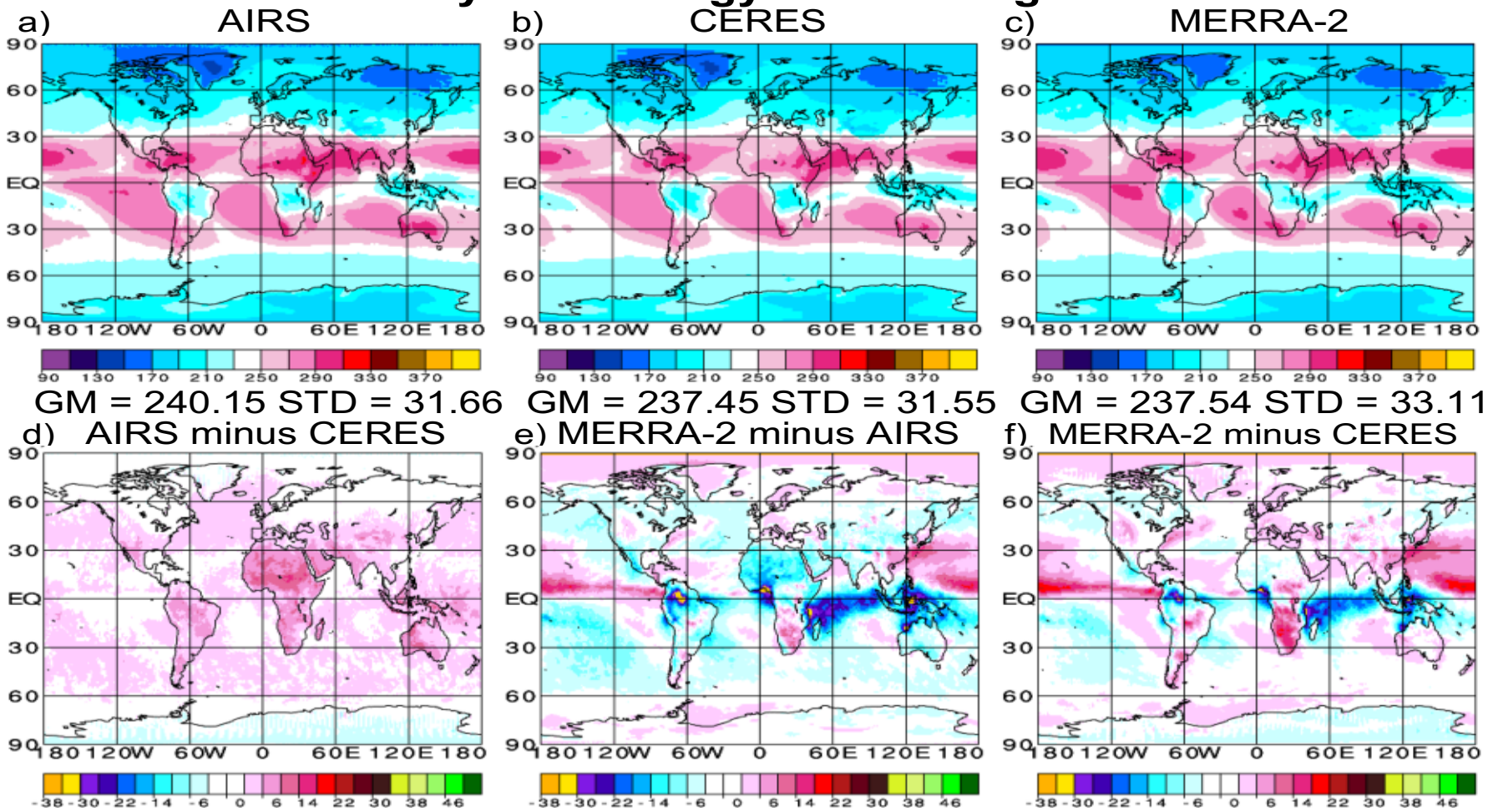


All OLR data sets show similar, but not identical seasonal cycles. AIRS is biased about 3 W/m^2 high compared to CERES, with very small seasonal cycle differences. MERRA-2 OLR has larger seasonal cycle differences from AIRS and CERES, and appears to have a spurious negative OLR trend as well.

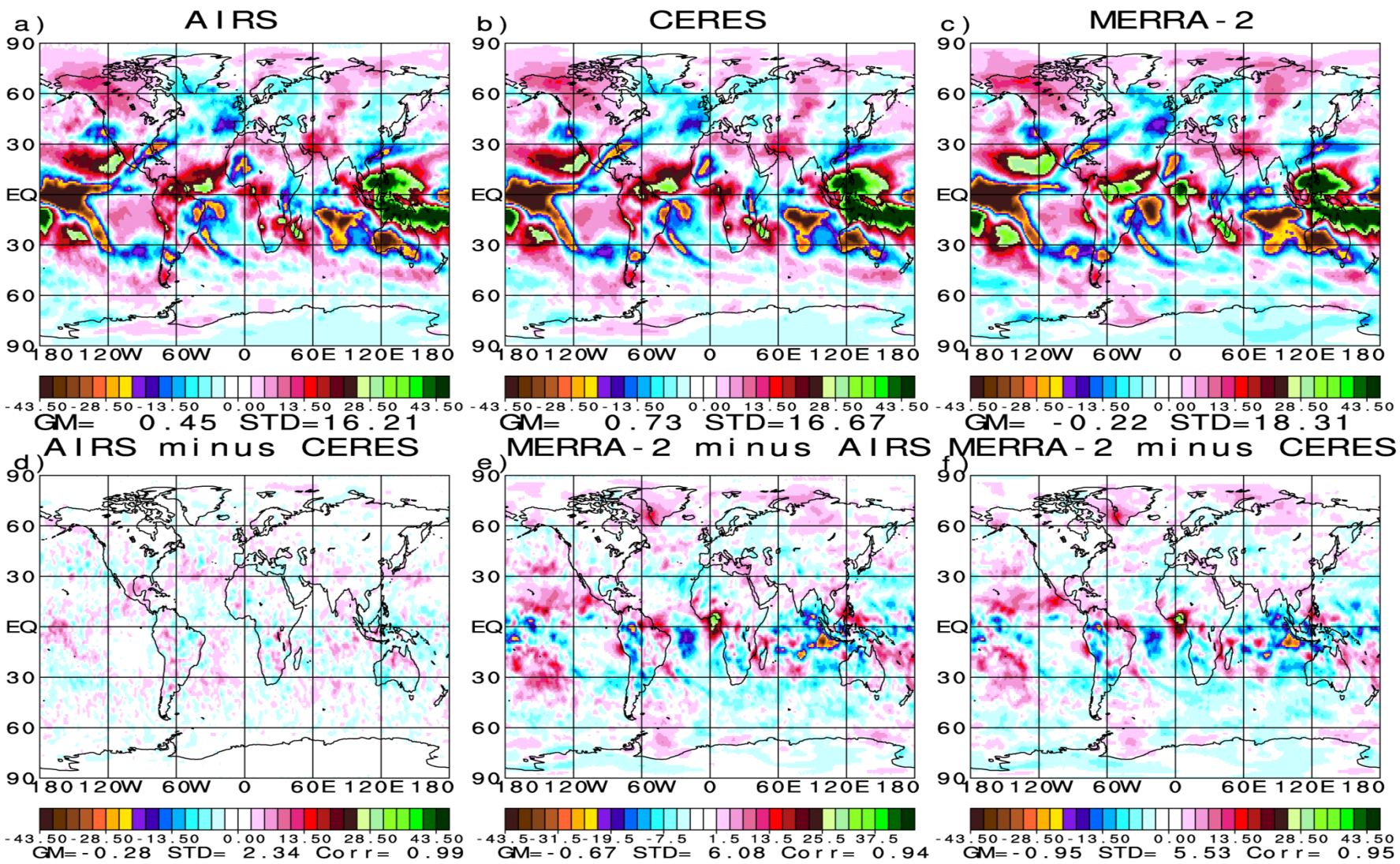
OLR Climatologies

- We generated AIRS and CERES and MERRA-2 monthly mean OLR climatologies for each month, on a 1˚ x 1˚ lat-lon spatial grid, by taking the average of the grid box value for that month over 14 consecutive years of that month: September-December, starting in 2002, and January-August, starting in January 2003.
- The OLR anomaly for a given month is defined as the difference of the monthly mean OLR value for that month, say January 2016, from the January climatology.

Outgoing Longwave Radiation (Watts/m^2)
January Climatology 2003 through 2016

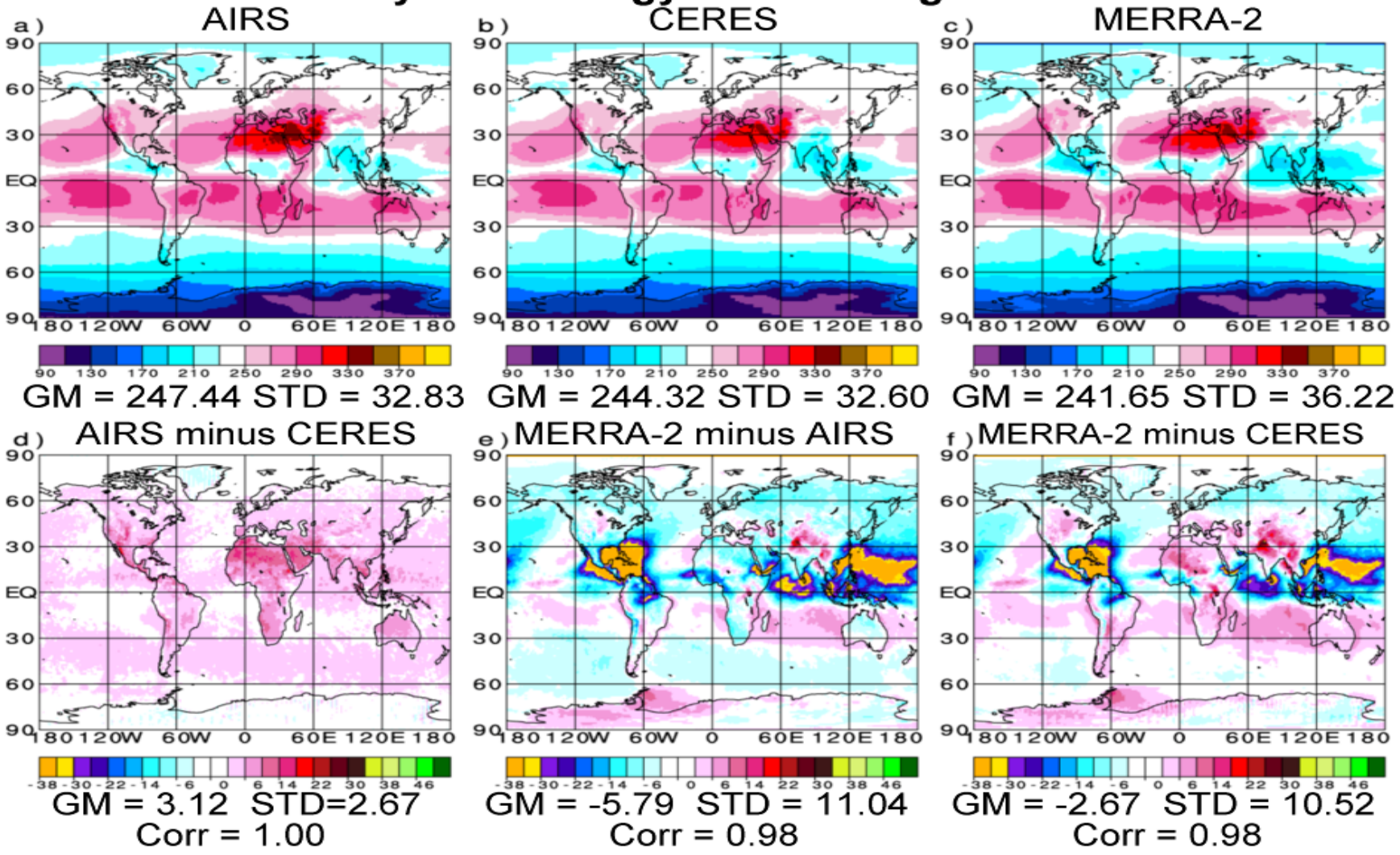


AIRS January OLR global mean climatology is 271 W/m^2 higher than CERES. The Spatial Standard Deviation (STD) of their difference is 2.58 W/m^2. The spatial differences are relatively flat. In the global mean sense, MERRA-2 is closer to CERES, but the STD of their differences is very large, with cancelling differences in the tropics.

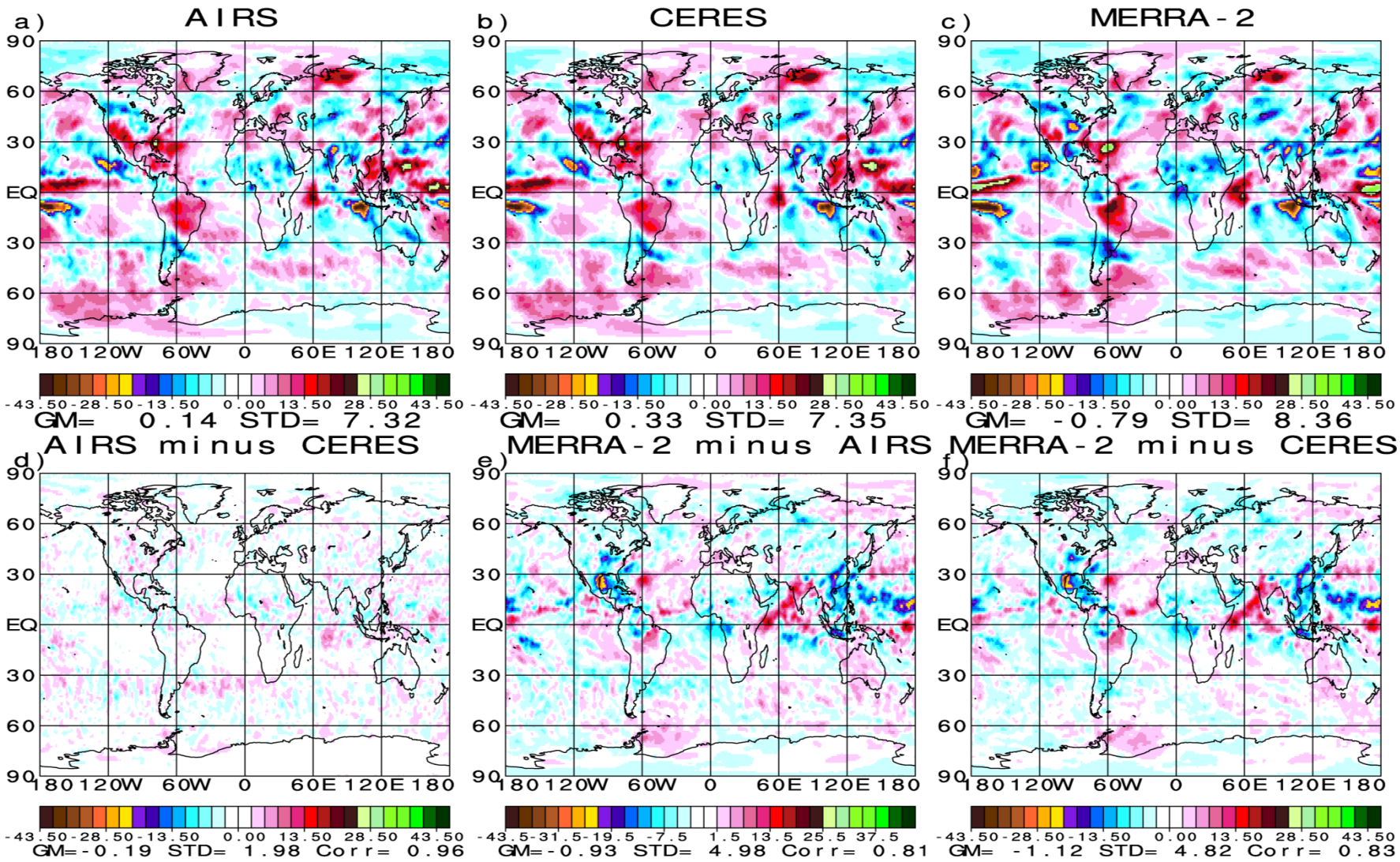


Large oscillating January tropical OLR anomalies result from El Niño induced changes in the locations of convective and subsidence activity. AIRS and CERES anomalies agree very well. MERRA-2 has large tropical anomaly differences compared to CERES. The GM MERRA-2 OLR anomaly is 0.95 W/m^2 lower than that of CERES.

Outgoing Longwave Radiation (Watts/m^2)
July Climatology 2003 through 2016

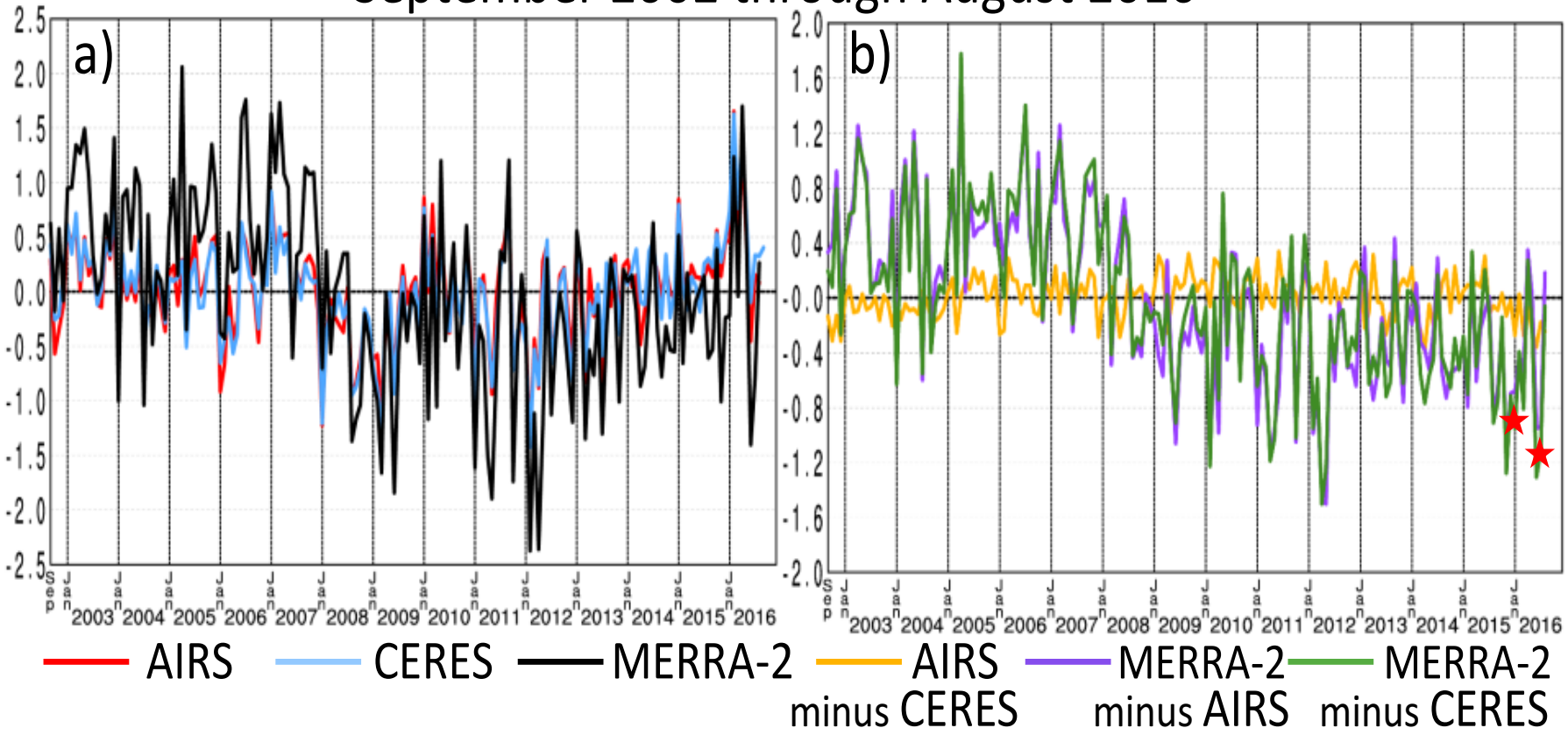


AIRS July OLR climatology again agrees very well with CERES in both the GM and STD sense. MERRA-2 July OLR climatology has extremely large differences from CERES in the tropics, and significant differences in the Northern Hemisphere extra-tropics as well.



As in January 2016, AIRS and CERES OLR anomalies match extremely closely. MERRA-2 July 2016 anomalies again differ significantly from CERES in the tropics and the MERRA-2 GM anomaly is again 1.12 W/m^2 lower than CERES.

Global Outgoing Longwave Radiation Anomaly (Watts/m^2)
September 2002 through August 2016

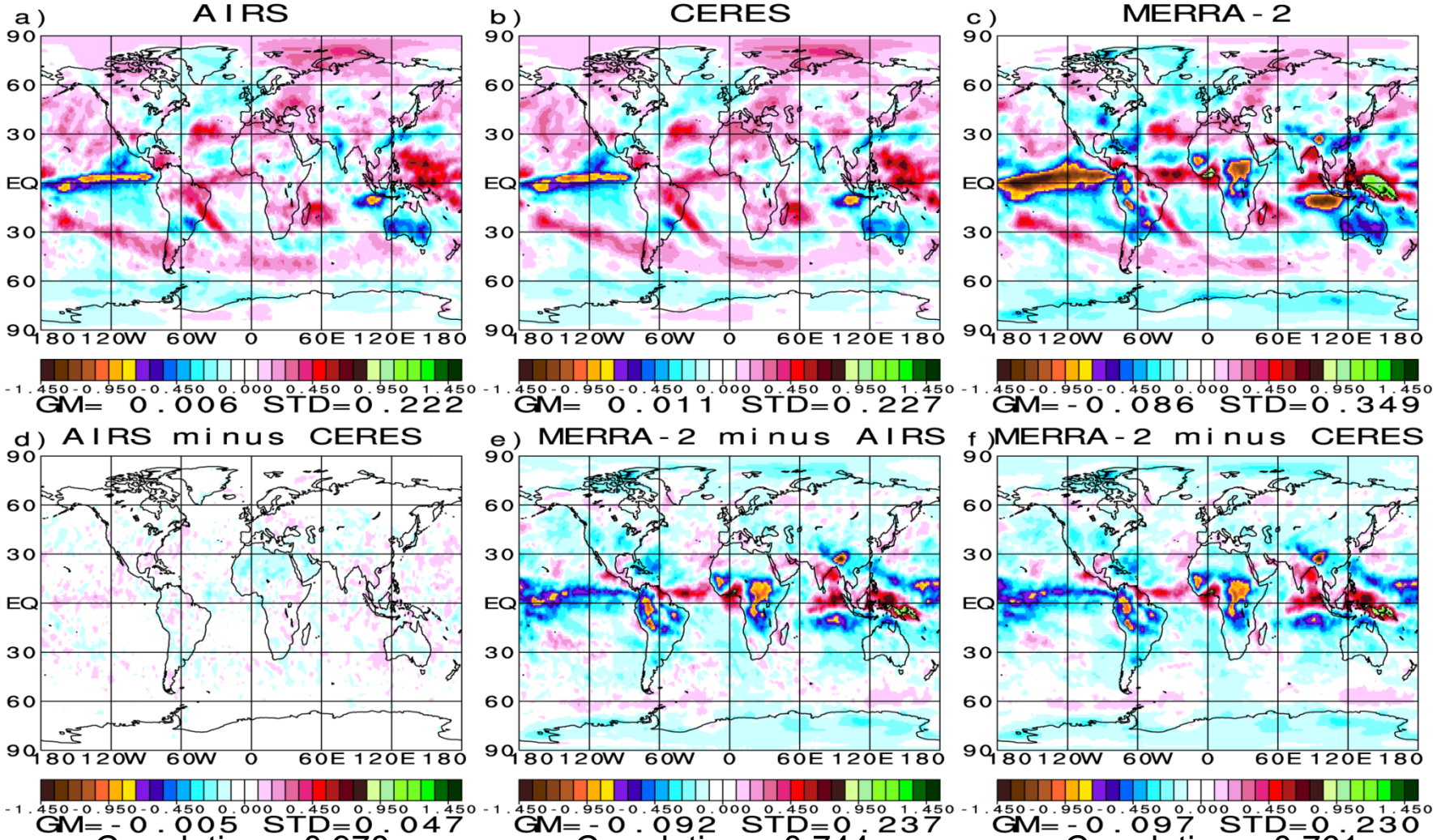


AIRS and CERES Global Mean OLR anomalies typically match to within 0.2 W/m^2 throughout the time period under study. MERRA-2 OLR anomalies are significantly more positive than those of CERES and AIRS before January 2009, and significantly more negative after that date. Something changed in MERRA-2, perhaps resulting from a new data source used in the analysis.

Average Rates of Change (ARCs)

ARCs are defined as the slope of the linear least squares fit to an anomaly time series. ARCs are analogous to short term trends, but they do not necessarily represent trends at all. Rather, ARCs can be strongly influenced by large anomalies at the beginning and/or at the end of a time series. ARCs can therefore be very dependent on the precise time period under study. ARCs are nevertheless very informative as to what has happened over the time period under study. Spurious ARCs can depict problems with a data set.

OLR ARCs (W/m^2/yr) September 2002 through August 2016



Correlation = 0.978 Correlation = 0.744 Correlation = 0.761

AIRS and CERES show a very slight global mean increase in OLR. Both agree very well in all details. MERRA-2 show a large spurious decrease in OLR, which occurs almost everywhere, especially in the tropics. El Niño induced OLR ARCs are greatly exaggerated and contains spurious negative features over Africa and South America.

Conclusions

AIRS and CERES OLR time series agree extremely well in all aspects. This agreement validates the results of both data sets. AIRS also complements CERES in that it provides the retrieved geophysical parameters used in the calculation of AIRS OLR. Agreement of AIRS OLR with CERES also validates to some degree the AIRS retrieved geophysical parameters.

Some aspects of the MERRA-2 OLR data set perform reasonably well. MERRA-2 OLR has two serious short-comings however:

1) The MERRA-2 OLR data set has a discontinuity which results in a large spurious global mean 14 yr. OLR trend.
2) MERRA-2 OLR has very large errors in the tropics related to convective cloud cover.